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ABSTRACT

This study investigates (1) the relationship of two potentially valuable measures of sequential processing to each other and to a measure of digit span, and (2) the relationships among tests of sequential processing and other measures of cognitive functioning. Subjects were 188 first grade students who had been screened in kindergarten for risk of later learning disabilities. Fifty-nine children had been tested with SEARCH (Silver & Hagan, 1976) and 62 had been tested with the McCarthy Screening Test (MST). After school opened, a game called Electric Simon was administered individually to each child and a film test called Serial Integration was administered to class size groups. Performance on the Electric Simon game correlated significantly with a digit span measure -- the Numerical Memory sub-test of the MST. Simon scores also correlated highly with the total SEARCH score. Film test performance was not correlated at a significant level with the Numerical Memory sub-test. SEARCH Rote Sequencing sub-test scores correlated more highly with the game than with the film. Further, the Simon game exhibited significant correlations with all but one of the SEARCH sub-tests and a consistent pattern of low but significant correlations was found between the Simon game and most of the MST sub-tests. Electronic Simon is thought to be a useful tool for research of sequential processing ability. (Author/RH)

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MEASURING SEQUENTIAL PROCESSING SKILLS IN YOUNG CHILDREN

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by

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Summary

Measuring Sequential Processing Skills in Young Children

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Widely used procedures for measuring sequential processing skills are not highly reliable and there is uncertainty regarding the actual cognitive processes being measured. Two experimental tests of sequential processing are described and data are presented for 188 first grade children for the experimental tests and for two pre school screening tests. The findings suggest that at least one of the experimental measures holds promise as a new procedure for measuring sequential processing skills.

Measuring Sequential Processing Skills in Young Children

Problem

Luria (1973) has described two fundamental ways in which information is perceived and organized during cognitive activities: successive and simultaneous processing. Successive processing deals with the organization and retention of stimuli perceived in sequential order and is primarily concerned with temporal organization. Simultaneous processing refers to the organization of stimuli perceived at any given instant and is concerned primarily with spatial organization. Torgersen (1978-1979), in a comprehensive literature review finds measures of successive processes consistently related to reading proficiency. Torgersen notes that measures of successive processing have been limited to one or two widely used procedures, the digit span subtest of the Wechsler Intelligence Scale for Children and the sequential memory subtest of the Illinois Test of Psycholinguistic Ability.

The digit span test appears on the surface to be simple enough, requiring a repetition of a string of numbers dictated by the examiner. Estes (1974), however, notes a number of factors that could cause a child to fail to achieve on this task. Such reasons include lack of familiarity with ordinal

numbers, little experience in using number sequences, failure to use grouping strategies, inability to use chunking, and inability to inhibit output. More generally, Estes makes the point that we have not subjected such measures to sufficient experimental work to know what precisely is being measured by such tests and that we are, thus, left with little basis on which to design remedial programs for individuals exhibiting deficiencies on these measures. It is not entirely clear whether digit span is measuring language encoding processes (Perfetti and Goldman, 1976), attention (Tarver and Hallahan, 1974) or a variety of other possible variables.

The use of digit span as a measure of sequential memory is further complicated by evidence that the need to respond through spoken procedures may interact with short-term memory. Poppen, Stark, Eisenson, Forrest and Wertheim (1969) found that aphasic children as a group are inferior to normal children on a number of tests of sequencing ability. The difference between the groups was particularly marked on the tests which required the use of language.

Such studies establish the importance of exploring alternatives to digit span as a means of measuring sequential memory, particularly measurement procedures which by-pass verbal mediation of the response.

Two instruments which offer promise as measures of

sequential processing are Electronic Simon, a game distributed by Milton Bradley and Serial Integration, a film test designed specifically to measure sequential processing skills (McDaniel, Durham and Smith, 1975).

Electronic Simon is a pancake shaped device about 12 inches in diameter with four differently colored panels (red, blue, yellow and green) on the top surface. When a start button is depressed, Simon presents a random sequence of lighted panels and simultaneously accompanying tones. The "player" reproduces the sequence by pressing the appropriate panels in the same order as the original pattern. After each successful reproduction, Simon adds one new light-sound stimulus to the original sequence, thus progressively increasing the difficulty until failure occurs.

Simon seems to offer a number of benefits over the commonly used measures of sequential memory. Since the time interval between stimulus elements is produced electronically, there is no variation from examiner to examiner in rate of stimulus presentation. The stimulus elements are relatively neutral and should not elicit number anxiety. Finally, response to Simon requires only gross motor abilities, thus by-passing verbal forms of response.

Serial Integration has a number of characteristics in common with Simon. Using Super 8 film, elements of simple geometric designs are presented on the screen one line at

a time. Students then turn the page of an answer booklet and choose from among three alternatives the design that would be formed by integrating the lines which have been viewed singly. As with Simon, the rate of presentation is strictly standardized across administrations, the stimuli are relatively neutral in emotional content, and only large motor activity is required in making a response.

Two major questions provided the central focus of this study:

1. What is the relationship of these two experimental measures of sequential processing to each other and to a measure of digit span?
2. What are the relationships among these experimental tests of sequential processing and other measures of cognitive functioning?

Procedure

Subjects The subjects for this study were 188 first grade students enrolled in six elementary schools in a small town in Indiana. The town serves as the commercial center for a predominantly agricultural region, and the children are all white.

Instruments During the summer prior to school opening, screening tests were individually administered to children enrolled in the Kindergarten program. Fifty-nine of the

children were tested with SEARCH (Silver and Hagin, 1976) and 62 of the children were tested with the McCarthy Screening Test. Both tests purport to identify children at risk for later learning disabilities.

SEARCH is comprised of 10 sub-tests:

Lamb Chop Matching (LCM) - Visual discrimination of asymmetric figures.

Lamb Chop Recall (LCR) - Immediate recall of asymmetric figures.

Designs (DE) - Visual-motor copying.

Rote Sequencing (RS) - Ordering rote sequences and elements verbally presented.

Auditory Discrimination (AD) - Discriminating between words that are identical or that vary by one phoneme.

Articulation (ARTIC) - Accurate production of specific sounds in words.

Initials (IN) - Associating sounds with their visual symbols.

Directionality (DIR) - Directional orientation.

Finger Schema (FS) - Location of tactical stimulation to fingers.

Pencil Grip (GRIP) - Development of opposition of finger and thumb.

A total SEARCH score may be obtained by summing the part scores.

The McCarthy Screening Test (The Psychological Corporation, 1978) consists of six subtests:

Right - Left Orientation (RLOR) - knowledge of right - left sides of body.

Verbal Memory (VM) - Memory for sequence of words and for word order within a sentence.

Draw-a-Design (DAD) - Design copying.

Numerical Memory (NM) - Digit span, both forward and backward.

Concept Grouping (CG) - Classification of objects by color, shape and size.

Leg Coordination (LC) - Walking backwards, tiptoeing, standing on one foot, etc.

A Total McCarthy score was generated by summing the subtest scores.

Electronic Simon was administered individually. After two practice trials, 12 trials with Simon were administered. Children responded to six of the trials with the preferred hand and to six with the non-preferred hand. The Simon Scoring Sheet is attached.

Serial Integration was administered to class size groups. A Kodak MFS-8 projector was used to project the stimulus material for the 26 items of the test. The projector was stopped after each item while the children marked their answer booklets.

Data Analysis

A correlation matrix was generated for all test scores and sub-test scores obtained.

Findings

The major findings, the correlations among Simon, Serial Integration, Total SEARCH, Total McCarthy and Numerical Memory are shown in Table 1.

Table 2 presents the relationships amont the SEARCH sub-test scores and the two experimental measures of sequential processing. Table 3 presents the correlations among the McCarthy sub-scores and the two experimental measures of sequential processing.

Since Simon has not previously been administered to a large group of children, some record of performance on this device may be useful. Table 4 presents the frequency distribution of the scores for 12 trials of Simon under the conditions described.

Discussion

From Table 1, it is evident that Simon, which was proposed as an alternate measure to digit span, does correlate significantly with Numerical Memory, a digit span task. Simon also correlates highly with the total SEARCH score suggesting that Simon performance may depend as much on general perceptual-cognitive maturity as on a specific

sequential processing skill.

The correlation coefficient between Simon and the film test of sequential processing is significant ($<.01$), but the absolute value is not impressive, .27. The film test itself is not correlated at a significant level with Numerical Memory.

These apparently contradictory findings may be meaningfully interpreted if one keeps in mind a distinction made by Fraisse (1978). Fraisse makes a distinction between the apprehension of successive events into an integrated unit, and the memory for a series of stimuli based primarily on their temporal order. On the film test, the separate lines must be integrated into a meaningful unit, a geometric design. For digit span and Simon, only the memory for order seems to enter into performance.

Fraisse notes that where only temporal order is involved, as in rhythmical structures, little increase in performance is observed from childhood to adulthood. However, when cognitive processes can intervene in the organization or chunking of the stimuli, increases in performance with age are noted.

If one considers that the film test may be measuring conceptual organization and that Simon is measuring temporal organization, then some expectations may be established

about the relationships among each of these measures and selected sub-tests of the screening instruments.

For SEARCH, Rote Sequencing would seem to offer promise for a high correlation with Simon, but inspection of the items indicates that this sub-test may be misnamed. The test appears to measure the extent to which the child has already learned common ordered sequences, "What comes after the number five?" Thus, there is no reason to expect the correlations of this sub-test with Simon to be any higher than the correlations with the film test. Inspection of Table 2, however, does show a higher relationship between Rote Sequencing and Simon than between Rote Sequencing and Film. Indeed, Simon exhibits significant correlations with all of the sub-tests of SEARCH except Lamb Chop Recall, a test of short-term visual memory. At this writing, the pattern of correlation exhibited does not suggest a ready interpretation about the meaning of the Simon scores.

Considering the sub-scales of the McCarthy, mention has already been made of the expectation of high correlations between the two experimental tests of sequential processing and the Numerical Memory score. Additionally, a high correlation was anticipated between the Conceptual Grouping score and the film test. Inspection of Table 3 confirms the first expectation but not the second. Again,

a consistent pattern of low but significant correlations is evident between Simon and most of the McCarthy sub-tests. No interpretation is advanced for these relationships.

Table 4 indicates the wide range of performance obtained on Simon for this sample of first grade children. Observationally, it was striking to note that some of the first grade children tested had great difficulty reproducing even a two element sequence. The examiners ultimately learned to take the hand of the child and provide guidance through the required sequence of movements. Other children delightedly reproduced strings of up to 12 elements.

In summary, the measurement of sequential processes in children is now being accomplished by a very limited set of procedures. The underlying construct of sequential processing has not been defined with great precision. Multiple methods of measuring sequential processing should assist in better defining the underlying skill involved and in learning more about the role of this skill in early school learning. Electronic Simon appears to be a useful tool for continued research in this area.

Table 1

Correlations Among Simon, Film Test, Total SEARCH

Total McCarthy and Numerical Memory

	TOTSIM	FILM	TOTSERH	TOTMAC	NM
TOTSIM	1.0000 (182) P= .001	.2736 (173) P= .001	.5762 (59) P= .001	.3301 (59) P= .005	.5381 (58) P= .001
FILM	.2736 (173) P= .001	1.0000 (179) P= .001	.2907 (57) P= .014	.1679 (59) P= .102	.1951 (58) P= .071
TOTSERH	.5762 (59) P= .001	.2907 (57) P= .014	1.0000 (59) P= .001	99.0000 (0) P=******	99.0000 (0) P=******
TOTMAC	.3301 (59) P= .005	.1679 (59) P= .102	99.0000 (0) P=******	1.0000 (62) P= .001	.7729 (61) P= .001
NM	.5381 (58) P= .001	.1951 (58) P= .071	99.0000 (0) P=******	.7729 (61) P= .001	1.0000 (61) P= .001

(COEFFICIENT / CASES / SIGNIFICANCE)

(99.0000 MEANS UNCOMPUTABLE)

Table 2

Correlations Among Simon, Film Test and Sub-Tests of SEARCH

	TOTSIM	FILM
LCM	.3266 (59) P= .006	.2835 (57) P= .016
LCR	.1130 (59) P= .197	.2075 (57) P= .061
DE	.2996 (59) P= .011	.1653 (57) P= .110
RS	.2724 (59) P= .018	.1051 (57) P= .218
AD	.4360 (59) P= .001	.1561 (57) P= .123
ART	.3694 (59) P= .002	.1328 (57) P= .162
IN	.4664 (59) P= .001	.2832 (57) P= .016
DIR	.4601 (59) P= .001)	.0822 (57) P= .272
FS	.3058 (59) P= .009	.2147 (57) P= .054
GRIP	.2329 (58) P= .039	-.0237 (56) P= .431

Table 3

Correlations Among Simon, Film Test and Sub-Tests of the McCarthy

	TOTSIM	FILM
RLOR	.2421 (59) P= .032	.0330 (59) P= .402
VM	.2899 (58) P= .014	.1543 (58) P= .124
DAD	.1267 (58) P= .172	.0469 (58) P= .363
NM	.5381 (58) P= .001	.1951 (58) P= .071
CG	-.0122 (58) P= .464	.1414 (58) P= .145
LC	.2081 (58) P= .058	-.0635 (58) P= .318

Table 4

Frequency Distribution and Cumulative Percent
For Total Simon Score

CODE	FREQ	ADJ PCT	CUM PCT
13.	2	1	1
15.	1	1	2
16.	1	1	2
17.	1	1	3
18.	2	1	4
21.	2	1	5
22.	1	1	5
23.	2	1	7
24.	1	1	7
25.	1	1	8
27.	1	1	8
29.	2	1	9
30.	3	2	11
31.	1	1	12
32.	3	2	13
33.	2	1	14
34.	3	2	16
35.	3	2	13
36.	3	2	19
37.	2	1	20
38.	1	1	21
39.	1	1	21
40.	1	1	22
41.	3	2	24
42.	2	1	25
43.	5	3	27
44.	5	3	30
45.	2	1	31
46.	4	2	34
47.	9	5	38
48.	6	3	42
49.	10	5	47
50.	7	4	51
51.	6	3	54
52.	8	4	59
53.	5	3	62
54.	6	3	65
55.	5	3	68
56.	5	3	70
57.	7	4	74
58.	8	4	79
59.	5	3	81

Table 4 cont'd

CODE	FREQ	ADJ PCT	CUM PCT
60.	8	4	86
61.	2	1	87
62.	3	2	88
63.	3	2	90
64.	1	1	91
65.	3	2	92
67.	3	2	94
68.	1	1	95
70.	2	1	96
71.	1	1	96
72.	1	1	97
73.	1	1	97
75.	1	1	98
77.	1	1	98
81.	2	1	99
89.	1	1	100

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Footnote:

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